



Building back better for increased resilience of the UK food system to future shocks





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Executive summary

The UK food system both comprises and depends upon an intricate web of relationships and activities, which operate at a global scale, making it vulnerable to disruption on many levels and in different ways for different people. The shock of COVID-19 in 2020 highlighted this, exposing a variety of socio-economic, geographic and logistical vulnerabilities, which resulted in greater impact on some activities and individuals than others. Crucially, such vulnerabilities also expose the UK food system to other shocks and disruptions in the future and have highlighted the need to 'build back better' by increasing the resilience of the UK food system in anticipation. This report highlights potential future shocks and the research, innovation and relationships required to understand and manage such risks, and to support a thriving, resilient food system, which minimises disruption and maintains food security in future.

'Build back better' emerged as an overriding theme from an initial expert working group convened by the Global Food Security Programme (GFS) and Biotechnology and Biological Sciences Research Council (BBSRC) to develop thinking on the impacts of COVID-19 on the food system. This global assessment provided recommendations for research and innovation opportunities and challenges in the immediate, short and medium term. The subsequent stakeholder workshop informing this report explored what 'build back better' means, in practical terms, for a UK food system that is resilient to a much wider range of potential future shocks. This report outlines key research and innovation opportunities, topics and potential relationships generated in the workshop.

Although a number of potential disruption scenarios are possible, the most common themes predicted are combinations of extreme weather associated with climate change, and the potential impacts of a second wave of COVID-19 in winter 2020-21. However, a key message is, there are myriad possible disruptions and so interventions aimed at improving resilience should be beneficial in multiple, and potentially simultaneous, disruption scenarios.

What enhanced resilience of the UK food system would look like as part of a programme of 'build back better':

- From an agricultural perspective, research into improving the UK's soil health is crucial, alongside the development of enhanced climate models. Measures to address the UK's ageing farmer base are also identified as important.
- Local food production is a useful supplement to globalised supply and demand, alongside improved data sharing within supply chains and a greater ability of producers and manufacturers to 're-pivot' their activities in a disruption scenario.
- Expansion of plant-based protein and fruit and vegetable production in the UK through enhanced inter- and intra-crop species diversification is important, not only to reduce risk from disruption to supply but also to better ensure the UK can meet its nutritional needs in any future disruption scenario.
- Understand the complex range of factors influencing nutrient uptake and consumer dietary choices and the potential for enhancing the nutritional value of foods. This is alongside the role of diet in COVID-19 related deaths and an underpinning need to improve overall dietary health.
- At a supply chain level, there is a need to identify ways to buffer just-in-time systems against food shortages. Solutions should focus on adaptability, for example, by utilising emerging technologies, such as digital twins, which can help different supply chain actors react to a disruption in concert rather than isolation.
- In order to facilitate a more resilient UK food system, stakeholders are clear that research and innovation needs to be interdisciplinary and international and that applied research must be adequately funded.

It is essential that any research and development opportunities are systemic. If implemented in a piecemeal fashion, resilience will not necessarily ensure that food is affordable, accessible, safe, healthy and produced in a way that underpins, and benefits from, a thriving natural environment. These areas must therefore be consciously enshrined in designs for food system resilience.



Background to the workshop

Building back better for increased resilience of the UK food system to future shocks

This multi stakeholder workshop built on the findings of a previous working group, 'COVID-19 and global food systems: How can research and innovation help respond to the crisis?', convened by GFS and BBSRC in May 2020 to develop UK Research and Innovation's (UKRI) thinking on the impacts of the Coronavirus disease (COVID-19) on the food system. The initial working group explored the immediate impacts of COVID-19 on UK and global food systems and provided recommendations for research and innovation opportunities and challenges in the immediate, short and medium term.

A key theme that arose from this working group was the importance to 'build back better' a more resilient UK food system.

In July 2020 GFS and BBSRC hosted a workshop with a range of stakeholders from across the UK food system to determine the research and innovation needs and opportunities around 'building back better' and how this might enhance the resilience of the UK food system to future shocks.

The aims of the workshop:

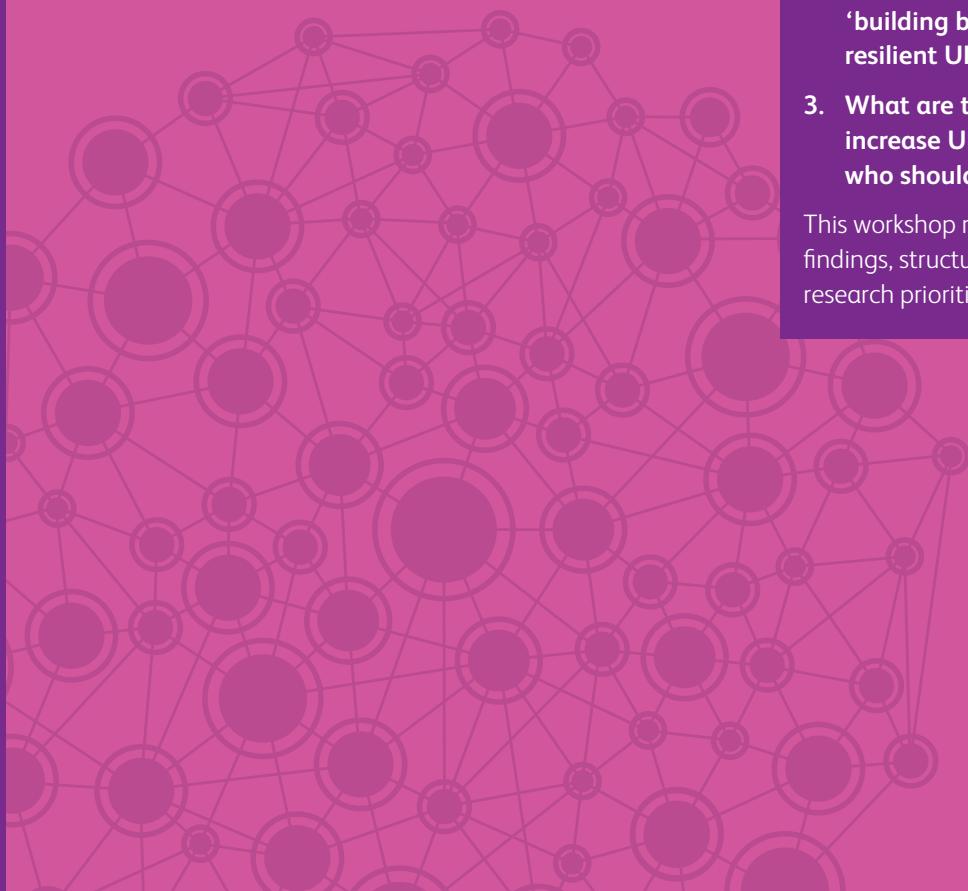
- To determine what a more resilient UK food system would look like within the context of 'building back better' for a green economic recovery and availability of safe, healthy and nutritious food for all.
- Understand the research and innovation priorities, opportunities and challenges.
- Understand key stakeholders to address priorities.

The workshop was multidisciplinary in nature including academics, industry, non-governmental organisations (NGOs) and policy makers. The workshop consisted of parallel breakout groups and a plenary session in which all attendees reconvened and to which members of GFS' Programme Coordination Group were invited.

Discussions were focussed around the following questions:

1. What types of shocks might the UK food system face in the future?
2. In the context of these shocks, what does 'building back better' look like for a more resilient UK food system?
3. What are the key research priorities to increase UK food system resilience and who should UKRI partner with?

This workshop report brings together the key findings, structured around common themes and research priorities that emerged for each question.





What types of shocks might the UK food system face in the future?

Long term impacts associated with the COVID-19 pandemic, and the potential of a second wave, were considered as future shocks to the UK food system:

- COVID-19 has resulted in significant changes to how we consume food in the home and as a social function, as well as the types of food we consume and how we access them. It is currently unclear what the lasting impacts will be, but some sectors will certainly be affected more than others (e.g. hospitality was affected significantly more than retail) and this could have implications for the future resilience of the UK food system.
- Overall, the food system worked well during COVID-19 but there were barriers to access (e.g. shielding, ill health, physical remoteness, transport). These barriers were particularly acute for those on low income, to those from ethnic minorities, or where cultural issues were concerned. Current coping mechanisms such as food banks can fail and situations have occurred where clinically vulnerable Muslim households were sent packages from food banks containing pork¹, which can undermine trust in the food system.
- An anticipated second wave of COVID-19 in the UK could cause further food system shocks and contribute to a deeper recession. If a second wave occurs in winter, the nature of the northern/southern hemisphere global harvesting system would mean the UK food system could be more susceptible to supply side shortages. This could lead to more severe food shortages than were seen in the first wave and which were largely due to transport/packaging reconfiguration limitations.
- Continued human encroachment into wilderness environments is concerning and, combined with the effects of globalisation, increases the likelihood for new diseases to emerge and spread that could impact the food system similarly to COVID-19.

¹ Food Foundation (2020). Government accused of insensitivity after sending shielding Muslims pork in food packages. <https://foodfoundation.org.uk/vulnerable-groups/?paged1=3&paged2=1>

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It is recognised that the food system is constantly operating under stress factors. Primary production faces challenges, including climate change, pest and disease threats, reduction in resources (e.g. water, phosphate) and decline in ecosystem services. Therefore, it is essential to build resilience, to be as prepared as possible to future shocks, such as:

- **Extreme weather.** Climate change makes it increasingly likely that extreme weather events will increase in severity and occurrence (e.g. heavy rainfall followed by high heat and dry weather) causing significant disruption to food production, distribution and storage. It is one of the highest risk shocks likely to face the UK food system in future.
- **Loss of ecosystem services.** The UK food system is dependent on a range of ecosystem services both in the UK and the countries that supply the UK with food. These ecosystem services range from soil fertility and water provision to pollination and pest control and all of these services show varying levels of decline globally². If not reversed, not only could yields be affected but other shocks, including flooding, drought and outbreaks of pests and diseases, are likely to become more common.
- **Specific crop or animal pests or diseases or food borne pathogens.** This could include foot and mouth disease, plagues of locusts or *E. coli* 0157. Animal diseases are also intrinsically linked to human disease via zoonotic events and due to livestock acting as a possible reservoir for anti-microbial resistance.
- **Food fraud.** Food fraud is identified as a potential safety, and consumer trust, risk. It can occur where lower value and potentially harmful ingredients are substituted for more expensive ingredients. Not only is it detrimental to consumer safety but can result in disruptive recalls. The 2013 horse meat scandal is an example.
- **Export bans.** In some situations where availability of a key commodity drops, countries can impose export bans and, depending on the level at which that commodity is traded internationally, global prices can be affected. The 2007/08 food price spikes due to export bans on rice from Asia is an example and led to food riots and political instability. Panic buying can exacerbate such price spikes significantly and there is a need to better understand consumer behaviours that result in panic buying.



- **Trade wars.** There is concern that geopolitical events, such as trade wars (e.g. US and China) and sanctions, (e.g. US/Europe and Iran) have the potential to add significant volatility to food supplies locally and globally. Another example is the UK's departure from the EU; until trade deals are agreed, the UK will have to trade according to World Trade Organisation 'most-favoured-nation' terms. This means that the UK will not have preferential access to certain commodities over other nations and it could restrict access to food supplies in a global disruption scenario.
- **Conflict** is a major potential shock, with risk being highest if it occurs in volatile regions (as it may be harder to anticipate) or major food producing regions. The larger the conflict (e.g. other nations becoming involved or weapons of mass destruction being used) the higher the risk to UK food resilience as global trade/energy supplies are more likely to be impacted. Importantly, conflict can itself be a symptom of a lack of food system resilience as the Arab Spring demonstrated in the early 2010s.
- **Energy prices.** Disruptions to energy supplies at various points around the world could increase the cost of agricultural inputs, food commodities, transport and storage costs, all affecting UK food system resilience.
- **Bioterrorism.** The possible deliberate use of biological agents against either crops or livestock, or directly against civilian populations, is a possible shock to the UK food system, whether occurring domestically or abroad.

2 IPBES (2019): Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany.

3 Garnett, P., Doherty, B. & Heron, T. Vulnerability of the United Kingdom's food supply chains exposed by COVID-19. Nat Food 1, 315–318 (2020). <https://doi.org/10.1038/s43016-020-0097-7>

■ **Labour shortages.** The horticulture sector is heavily dependent on manual labour at harvest time. Much of this labour is employed from outside the UK, raising concerns that a variety of future shocks, including pandemics and politics (e.g. post Brexit migrant point system), could prevent or impact on harvest. Rural areas, unsociable hours and low pay are unattractive to UK workers. Similar concerns have been raised by the food and drink manufacturing sector, for example, suppliers of chilled ready-to-eat foods (e.g. supermarket sandwiches) rely on manual labour.

■ **Cyber risks.** In recent history, many stages of the UK food system, from manufacturing through to logistics and retail, have become more concentrated and horizontally integrated. At the same time, they have become increasingly digitised and this leaves many of these stages vulnerable to cyberattack.

It is important to note that many of the aforementioned shocks can occur in tandem, for example; fog in ports limiting ability to import and export, combined with the effects of a trade war, and a second wave of COVID-19, or extreme weather events occurring in quick succession.

Shocks can also be exacerbated by high risk failure points. Again, considering ports; the port at Dover takes in the majority of the UK's food imports³. This presents a single point of failure because other UK ports either do not have the capacity or correct infrastructure to replace it in a disruption such as a major storm.



In the context of these shocks, what does 'building back better' look like for a more resilient UK food system?

Three key themes have developed for building back better:

Agriculture

Supply chain management

Diet, health and food safety

Agricultural considerations

Reversing declining soil quality

- Currently a third of land globally is moderately to highly degraded, which can result in reduced soil fertility and increased susceptibility to flooding and drought. Productive soil loss is a major risk factor for crop failure and food security and there is a need for more research on soil maintenance and restoration techniques⁴.

Workforce

- It is known for farmers to leave the industry, and new entrants discouraged from entering, due to the challenging nature of the role, difficulties in accessing and affording land and equipment, and low profit margins. The UK has an ageing farmer base, with the median age of farm holders being 60, and there is a need to plan for succession if domestic production levels are to be maintained, along with rural infrastructure and traditions.

Crop diversity

- UK agriculture focusses heavily on certain types of cereals, particularly wheat. This can be risky, as seen in 2020 when winter wheat yields were reduced by around 15% compared to 2019, and with more than 40% less sown, both due to inclement weather⁶. One way to reduce this risk is to expand what we grow domestically, both in terms of crop type and intra-species diversity (e.g. heritage varieties).
- There is an opportunity to produce more fruit, vegetables and wholegrains domestically, which are important for health, as discussed in the 2019 report of the EAT-Lancet Commission. In the UK the largest trade deficit in food groups is fruit and vegetables⁷.

- It was suggested that, whilst we do not have a protein deficit in the UK, more of the protein we consume could come from domestically grown plants.

Improving nutrient use efficiency

- Current dependency on nitrogen fertiliser, which is dependent on oil, is a potential risk as fluctuations in oil supply and/or price could limit availability of fertiliser. Both oil and phosphorus, another key fertiliser, are finite in supply and expected to peak in coming decades. Additionally, poor management of synthetic fertilisers can lead to environmental damage in the form of diffuse water pollution and soil degradation, further increasing susceptibility to extreme weather events. Agricultural resilience could be enhanced by improving the efficiency of fertiliser use, deepening understanding of emerging alternatives such as biofertilisers (microbial inoculants) and enhancing uptake of practices which preserve and increase organic soil fertility.

Animal and plant health

- Continued expansion of agricultural systems into previously untouched natural environments increases the risk of emerging animal and plant diseases. The highly globalised nature of the UK food system, combined with the effects of climate change (which may make the UK more accessible to previously unsuited pests and diseases), are exacerbating factors. To increase resilience there is a need to improve national capability and data to enhance the UK's ability to predict and identify threats, in order to reduce the likelihood of them becoming endemic, and to minimise the impacts if they do.

4 FAO and ITPS. 2015. Status of the World's Soil Resources (SWSR) – Main Report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy

5 Department for Environment, Food and Rural Affairs. 2016. Agriculture and Land Labour in the UK: Farm Structure Survey 2016.

6 UK Centre for Ecology and Hydrology (2020). High-tech data confirm record poor harvest after year of extreme weather. <https://www.ceh.ac.uk/press/high-tech-data-confirm-record-poor-harvest-after-year-extreme-weather>

7 Department for Environment, Food and Rural Affairs (2020). Food Statistics in your pocket: Global and UK supply. <https://www.gov.uk/government/publications/food-statistics-pocketbook/food-statistics-in-your-pocket-global-and-uk-supply#:~:text='Fruit%20and%20vegetables'%20has%20the, and%20%C2%A36.0%20bn%20respectively>

Supply chain management considerations

Shorter supply chains

- Shorter supply chains are perceived to be more resilient to disruption as visibility is often greater and exposure to global sources of disruption is reduced. However, shorter supply chains are still exposed to risks and whilst global supply chains, by design, can change suppliers rapidly this may not be possible if you have to source a product within a certain radius. Local supply chains are also not necessarily more equitable or healthy.
- An alternative option is to shorten supply chains virtually. Increased digitisation and transparency, combined with better modelling, can help large retailers to link local producers into their supply chains, exactly when produce is available, before moving onto other producers when it runs out. This shortens supply chains, potentially boosts local productivity and offers retailers security within their existing just-in-time operating system. Greater use of modelling will also enable life cycle analysis to provide information on sustainability, which is crucial for net zero goals.

Improving the way information is shared across the food system

- There is a need to continue to enhance traceability, which has benefits such as reduced susceptibility to food fraud and greater ability to market to different consumer demands (environmental standards, site of production, etc.).
- There is an opportunity to use data collected on consumer purchasing preferences by retailers to better understand how consumers change their shopping habits in disruption scenarios, such as COVID-19. This could allow supermarkets to more effectively anticipate demand responses to future disruptions. It would also enable long term study of whether changes in purchasing, such as more online shopping in response to COVID-19, are long lasting.

The ability of different sectors and/or supply chains to 're-pivot' activities during a disruption

- There is a need to understand the challenges facing different supply chains and/or component businesses in adapting to disruptive events. The ways in which different companies/supply chains substitute ingredients, re-manufacture products and find alternative customers in a disruption

scenario varies hugely from sector to sector.

The seafood sector is an example, heavily dependent on export and the domestic service sector. Adapting to a domestic, home based market, which perceives fish as a luxury and consumes it at home in relatively small quantities, has been very difficult.

- This ability to re-pivot is also really important for transport and packaging providers. It was an inability of these actors to adapt that hampered efforts to divert commodities from the hospitality sector to the retail sector in the COVID-19 disruptions, leading to unnecessary waste (e.g. millions of litres of milk not used in the food service sector⁸) and supermarket shortages (e.g. flour).

Revised food value

- Currently, much of the value of food is added at the processing and retail stage, not the agricultural stage. This is problematic because the low margins received by farmers do not always adequately reflect the labour or resources involved, or the ecosystem services that have enabled production. Consequently, there is an inherent lack of sustainability. However, as any increase in the cost of food could exacerbate existing access issues faced by citizens on the lowest incomes, interventions must be considered systemically and with consideration of support for these groups.

8 The Royal Association of British Dairy Farmers (2020). Q & A: Getting To Grips With The Impact Of Covid19 On Milk Supply Issues. <https://www.rabdf.co.uk/latest-news/2020/4/8/q-and-a-getting-to-grips-with-the-impact-of-covid19-on-milk-supply-issues?rq=covid>



Diet, health and food safety considerations

Diet and health

- COVID-19 has placed a spotlight on diet, with obesity being a major risk factor for mortality during the pandemic⁹. Improving population health through improved diet could significantly increase the UK's resilience to future pandemics. Micronutrient deficiencies within some segments of the population along with fibre deficiencies, more broadly, are also examples of where intervention is required.
- There is potential to enhance pre-farm gate nutrition density of crops, not just focus on nutritional fortification of foods during processing and retail. There are concerns that the UK is unable to feed itself with a nutritionally balanced diet, based on what is currently grown, in the absence of imports. A diversification of crops is recommended to address this, considering not just inter-species diversity, but also intra-species diversity, including heritage varieties of crops no longer grown in the UK.
- A number of concerns with current UK dietary guidelines exist. In addition, whilst the international benchmark diet proposed by the *Eat-Lancet* Commission aims to improve the nutritional health of the population, there are not enough fish in the sea to meet the dietary targets unless waste is significantly reduced and aquaculture increased¹⁰. Whatever the recommendations, access to more nutritious foods is not always easy for certain demographics depending on transport options and retailers in the immediate area, nor are they necessarily affordable.

Food safety

- There are consumer and industry concerns that food imports post-Brexit may have poorer safety, environmental and animal welfare standards (e.g. chlorinated chicken and hormone treated beef from the USA). Legislation on food standards will have a role to play here and the UK Government is reportedly considering a dual tariff system favouring imports that comply with UK standards. In principle, this would make lower standard produce more expensive and less likely to be imported, although there is scope for the situation to change.



Reducing asymmetric impacts of future disruptions on vulnerable groups

- COVID-19 has shown that certain groups within UK society can be disproportionately impacted by disruptions because of their unique situation; whether shielding, in ill health, physically remote, on low incomes or lacking transport. There are a number of potential policy interventions that could relieve some of this vulnerability, with suggestions including: extension of free school meals voucher schemes, reduction of the current Universal Credit five week initial wait, enhanced support for food banks, and those on low income and lacking transport who may be unable to access usual food outlets. However, there is unlikely to be a one size fits all solution and there is a need for further research in this area.

It is important to note that resilience is vital in ensuring continued food system functionality during a disruption, however it does not by default ensure that food is affordable, accessible, safe and healthy. Nor does it ensure that environmental challenges are included, or targets met (e.g. net zero). These areas must therefore be consciously enshrined in any designs for food system resilience.

9 Tan Monique, He Feng J, MacGregor Graham A (2020). Obesity and covid-19: the role of the food industry BMJ; 369 :m2237

10 Max Troell, Malin Jonell, Beatrice Crona (2020). The role of seafood in sustainable and healthy diets. https://eatforum.org/content/uploads/2019/11/Seafood_Scoping_Report_EAT-Lancet.pdf.

What are the key research priorities to increase UK food system resilience?

Four key themes have developed for research priorities:

Research
funding

Agricultural
research

Supply chain
management
research

Consumer
behaviour
research

Research funding priorities

The need to ensure that applied research is appropriately represented and funded

- Of the 700+ projects funded under the UKRI rapid response call for COVID-19, the majority were descriptive rather than applied. There is a need for more research in a living lab setting (on active farms or within manufacturing sites) in order to hasten transformation to a more resilient system and ensure research is directly applicable to real life situations. An example of a farmer led research initiative is [Innovative Farmers](#), a not for profit membership network, backed by a team from LEAF (Linking Environment and Farming), Innovation for Agriculture, the Organic Research Centre and the Soil Association.

- Current UKRI industry research partnerships often rely on cash contributions from industry partners to fund a research project. However, if the aim is to involve farms, small to medium enterprises, non governmental organisations and wider civil society, then alternative mechanisms for contribution should be considered, taking into account the resources and return on investment considerations of such partners. Furthermore, close involvement of industry partners in co-design of research and innovation was identified as a top priority.

The need for research to be interdisciplinary

- There is a need to ensure other science areas such as maths, physics, astrophysics, technology development, societal and modern data science are included in food system resilience research as it is fundamentally a complex problem that requires addressing with a whole system approach.
- There was a view that resilience could be an important topic for future bi-lateral partnership awards offered by BBSRC.

Agricultural research priorities

Crop diversification

- There is an opportunity to better utilise forgotten protein rich crops like nuts and pulses alongside a broader expansion of horticulture. There has been relatively little investment in these areas compared to crops like wheat and this has implications, including for protein self-sufficiency in the UK. Research is also required into better storage of food at all stages of the food value chain to minimise food waste.

Urban agriculture

- Increasing urban farming (indoor and outdoor) is also identified as a means for diversification; not as a replacement for conventional field production but to add resilience at key points of vulnerability. Part of the research need is to identify where these vulnerabilities are. Urban agriculture, particularly vertical, can be energy intensive meaning a sustainable energy supply is an important consideration.

Loosening the hold of stock markets in agriculture

- There is a need to loosen the bond between the stock market and farmers. As long as this bond determines what farmers grow and how much they are rewarded for it, other resilience considerations, such as crop diversification, will be secondary in concern.

Improved climate modelling

- There is an opportunity for improved modelling of climate change scenarios for multi-breadbasket failures. There is published data on virtual decline of US/China yield production and unpublished work looking at the countries that are the major importers of food to the UK¹¹. Modelling would need to consider temperature and extreme weather events as part of a wider model of the entire food system, describing other vulnerabilities, actors who would be affected by them, and the different durations.

Soil health

- There are opportunities for research into measuring soil health. New sequencing technology has revealed the diverse range of soil microbiomes and a better understanding of these could lead to huge breakthroughs in crop protection and carbon storage (with co-benefits for water and nutrition storage). Exploration of soil microbiomes should occur in tandem with the science of the gut microbiome. The goal would be an investible framework for soil health and partners could include retailers and carbon intensive companies that want to carbon off-set.

Supply chain management research priorities

Food stores

- No government food stores have existed in the UK since the 1980's, and retailers are keen to keep stock to a minimum to enhance efficiency. Any existing stores have typically been pushed onto logistics providers, which could prove a weakness in a disruption. It would be difficult for any single actor to bear the costs of taking on greater food stores alone, prompting a research opportunity to explore how this could be addressed at a supply chain and/or national level.

Digital twin technology

- Digital twin technology can capture complex real-world systems in a virtual model and allow accurate simulation of how a single change can generate system-wide consequences. For example, each farmer in the UK is supported by a range

of other businesses, supplying inputs from water and energy, to seeds, pesticides, mechanisation and processing. As margins can often be low for farmers, even small disruptions to any of these suppliers could have serious consequences. Digital twin technology could be a useful tool for conveying this information to farmers, or indeed stakeholders at any point in the food system, in a visually intuitive way without a need for prior understanding of the mathematical processes the digital twin is built on.

Understanding the link between population levels and UK food resilience

- What level of population can a resilient UK food system sustainably accommodate, given various assumptions or scenarios about resources, such as land use and water availability?

11 Ray DK, West PC, Clark M, Gerber JS, Prishchepov AV, et al. (2019) Climate change has likely already affected global food production. PLOS ONE 14(5): e0217148. <https://doi.org/10.1371/journal.pone.0217148>



Consumer behaviour research priorities

Transitioning to healthier diets

- Poor diets (resulting in obesity, associated health problems and poor dental hygiene) are linked to a higher lifetime cost to the NHS and COVID-19 has exacerbated inequalities¹². There was an increase in children admitted to hospital for malnutrition to almost 2,500 in the first six months of 2020, which is double the number over the same period in 2019. This is likely to be exacerbated by a recession following the COVID-19 pandemic. Information based strategies that tell people what they should be consuming are insufficient to generate long term dietary changes and there are a huge range of socio-economic factors that influence what people consume and how. There is a need to better understand the psychology that could enable transition to healthier and more sustainable diets, and address affordability, availability and acceptability.

The role of processed food in future disruptions

- Processed food has received a lot of negative publicity and can be perceived as a source of harmful additives when 'natural' is better. However, it must be remembered that not all food processing equates to nutritional decline, and processing can play a key role in extending the

shelf life of foods. This is important in ensuring continuity of supply during disruptions, not only in supermarkets, but also in food banks. Biofortification of long shelf life foods, such as rice/pasta/tinned goods, could provide a route to improve nutritional resilience in the UK during future disruptions and is an area open to further research from a food manufacturing and consumer acceptance perspective.

Understanding urban consumption

- Cities are hotspots of food consumption, with numerous socio-economic classes of consumers accessing and using different types of food in different ways. There is a need to consider how each of these consumer groups

- Access food
- Use food
- Prepare food
- Consume food at a particular time or in certain ways

For each of these points there is a need to consider how the structure of urban food supply chains, and pattern of food access points, influences resilience.

¹² University of Southampton. The cost of malnutrition in the UK economic report. <https://www.uhs.nhs.uk/ClinicalResearchinSouthampton/Research/Facilities/NIHR-Southampton-Biomedical-Research-Centre/Ourresearchandimpacts/Impactcasestudies/ThecostofmalnutritionintheUKeconomicreport.aspx>

Who should UKRI partner with to address these research priorities?

Priority partners for UKRI

Cross-Government:

- Department of Agriculture, Environment and Rural Affairs (DAERA)
- Department for Business, Energy & Industrial Strategy (BEIS)
- Department for Environment Food & Rural Affairs (Defra)
- Department of Health & Social Care (DHSC)
- Department for International Trade (DIT)
- Department for Work & Pensions (DWP)
- Food Standards Agency (FSA)
- Government Office for Science (GO-Science)
- HM Treasury (HMT)
- Local Authorities
- Public Health England (PHE) (National Institute for Health Protection from Spring 2021)
- Scottish Government
- Welsh Government

Within UKRI:

- A key partnership is needed between BBSRC and ESRC

Business and enterprise:

- Work with retailers on continuity planning (particularly which food products to prioritise in a disruption)
- Work with the food and drink manufacturing sector, particularly on automation, which could significantly reduce dependence on labour, thus improving resilience
- Work with the logistics sector on ability to adapt transport speed, capacity and type in a disruption

Inclusion of small and medium-sized enterprises (SMEs) is a priority for all of this work.

Community groups, NGOs and charities, including:

- Agriculture and Horticulture Development Board (AHDB)
- Food Foundation
- National Farmers Union (NFU)
- Responsible Use of Medicines in Agriculture Alliance (RUMA)
- Waste and Resources Action Programme (WRAP)
- Wellcome Trust

As for industry, there is a need for funding mechanisms that bring in these partners as equitable, costed collaborators to have respectful, meaningful and impactful partnerships.

Big data:

- Agrimetrics
- DeepMind
- The Alan Turing Institute
- Microsoft AI for Earth

Next steps

The findings from this report were presented to the Global Food Security Programme Coordination Group (PCG) in September 2020. The PCG consists of stakeholders from across UKRI, the Government, Devolved Nations and charitable foundations. The PCG was supportive of the challenges and research priorities identified and noted that resilience is a key issue and important policy driver across their organisations and departments. The initial response to the report is a mapping exercise in 2020 to explore existing research in the UK, and that funded through the UKRI COVID-19 fund, to identify synergies and to identify gaps and opportunities.

Attendees

	Sarah Baker	Agriculture and Horticulture Development Board
	Professor Richard Tiffin	Agrimetrics
	Barbara Bray	Alo-Solutions
	Dr Jamie Stone	BBSRC
	Dr Harriet Trewin	BBSRC
	Dr Louisa Jenkin	BBSRC
	Harriet Duncalfe	Berry Gardens
	Professor Judy Buttriss	British Nutrition Foundation
*	Professor Tim Benton	Chatham House
	Professor Tim Hess	Cranfield University
**	Joy Alexander	Department for Agriculture, Environment and Rural Affairs (DAERA)
**	Dr Duncan Harding	Department for Environment, Food and Rural Affairs (Defra)
**	Helen Rogers	Economic and Social Research Council (ESRC)
**	Dr Richard Bailey	Engineering and Physical Science Research Council (EPSRC)
	Evangelia Thoukididou	Food and Drink Federation
**	Professor Rick Mumford	Food Standards Agency (FSA)
	Carrie Bewick	GFS
	Dr Riaz Bhunnoo	GFS
	Andrew Morgan	Global 78
**	Kathryn Miller	Innovate UK
**	David Telford	KTN
	Professor Jess Davies	Lancaster University
	Caroline Drummond	LEAF (Linking Environment and Farming)
	George Clark	Marine Stewardship Council
**	Dr Ed Pope	Met Office
	Dr Helen Ferrier	National Farmers Union
	Dr Richard Harrison	National Institute of Agricultural Botany
**	Lisa Bettington	Natural Environment Research Council (NERC)
	Andrew Griffiths	Nestle
	Professor Sarah O'Brien	Newcastle University
	Dr Stella Peace	Nomad Foods
	Professor Michael Lee	Rothamsted Research
	Professor Tom MacMillan	Royal Agricultural University
	Sarah Blanford	Sainsbury's
	Dr Sofia Franco	Scottish Association for Marine Science
**	Dr Graeme Beale	Scottish Government
	Joanna Lewis	Soil Association
	Ben Reynolds	Sustain
*	Professor Margaret Gill	University of Aberdeen
	Professor Jennie Macdiarmid	University of Aberdeen
*	Professor Nicola Lowe	University of Central Lancashire
	Dr Peter Alexander	University of Edinburgh
	Professor Dan Bebber	University of Exeter
	Professor Michael Winter	University of Exeter
	Professor John Crawford	University of Glasgow
	Professor Steve Banwart	University of Leeds
	Professor Louise Dye	University of Leeds
*	Professor Simon Pearson	University of Lincoln
	Professor Bhavani Shankar	University of London
*	Dr John Ingram	University of Oxford
*	Professor Carol Wagstaff	University of Reading
*	Professor Peter Jackson	University of Sheffield
	Dr Samartha Thankappan	University of York
**	Susie Abson	Welsh Government

Key

- * Expert from working group: COVID-19 and global food systems
- ** Plenary observer

Attended COVID-19 and global food systems working group only

- * Professor Aled Jones Anglia Ruskin University



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Global Food Security (GFS) is a multi-agency programme, hosted by UK Research and Innovation, bringing together the main UK funders of research and training relating to food. GFS publications provide balanced analysis of food security issues on the basis of current evidence, for use by policy-makers and practitioners.

This report does not necessarily reflect the policy positions of the Global Food Security programme's individual partners.

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